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A comparison of the vulnerability of marine ecosystems to anthropogenic stressors

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A comparison of the vulnerability of marine ecosystems to anthropogenic stressors

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Introduction

The vulnerability (or sensitivity) of ecosystem components to stressors or threats is a key component of any environmental assessment and is increasingly used in environmental impact assessment, cumulative effects assessment and cumulative impact mapping. However, not all studies define vulnerability in the same way and this can lead to variable and incompatible results.

> "An ecosystem's vulnerability to a threat determines the impact of a threat on a species or ecosystem" - Halpern et al. 2007

Vulnerability is often arranged as a matrix between ecosystems/species and stressors to give a relative score for each pair (vulnerability matrix). Scores are determined based on expert-elicitation and/or literature review (Teck et al. 2010). Both cumulative impact mapping and risk assessments define and use such vulnerability matrices.

Methods

In order to examine commonalities and differences among studies, we synthesized scores and relative ranking provided in published vulnerability and risk assessment studies. We examined definitions, criteria, methodology, and resulting scoring and relative rankings in ten studies of vulnerability. In these studies, vulnerability scores were calculated using a number of criteria – spatial scale, temporal scale, intensity, change, and recovery. The most commonly used terms to define vulnerability are shown in the word cloud in Figure 1.

Figure 1: A word cloud diagram displays the words most commonly used to describe the components of vulnerability. The larger the word font, the more often it appeared.

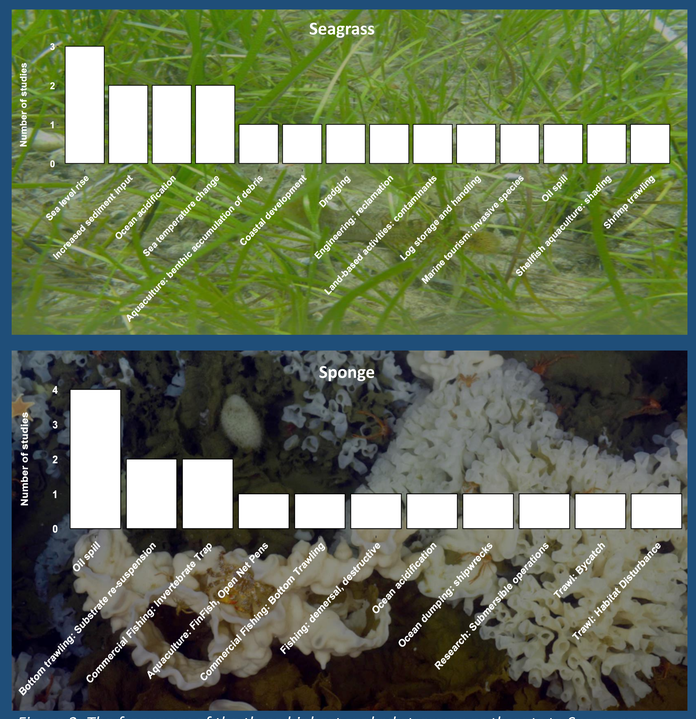

Figure 2: The frequency of the three highest ranked stressors as threats to Seagrasses (top) and Sponges (bottom). Seagrass and sponges were each evaluated in six of the ten studies.

Results

Vulnerability assessments have different scope, study area, components of interest, and stressors, making comparison difficult. However, there were some common components, and comparisons were able to be made with sponges (evaluated in six of ten studies) and seagrasses (six of ten). When the three highest impact threats for each study were compiled (Figure 2), sea level rise was the highest ranked threat for seagrasses (in the top three of 4 studies), whereas oil spill was the most often in the highest ranked threats for sponges (4 studies).

Nine of the ten studies included oil spill or inorganic pollution input as a stressor of interest, allowing a direct comparison of the vulnerability scores. The mean score for seagrass was 2.05 (± 0.3) and for sponges was 1.95 (± 0.3), each with a possible maximum of 3 (Figure 3). The spread in the data demonstrates that the criteria used and the study system will affect the resulting vulnerability scores. Care must be taken in transferring scores defined in one system (e.g., California current) to other systems of interest such as has been done for studies on British Columbia, Canada and Bering Strait, Alaska.

Moving forward

Vulnerability scores give a relative assessment of the impact of a stressor on an ecosystem or its components. This comparison of vulnerability definitions and rankings across different assessments will advance the understanding of cumulative effects assessments and the management of the risk of stressors.

In the next phase, we will produce a new vulnerability matrix for risk- and cumulative effects assessments in Canadian marine ecosystems built upon and informed by our review of existing vulnerability assessments. The updated vulnerability matrix will be used in cumulative impact mapping to inform marine spatial planning and ecosystems-based management.

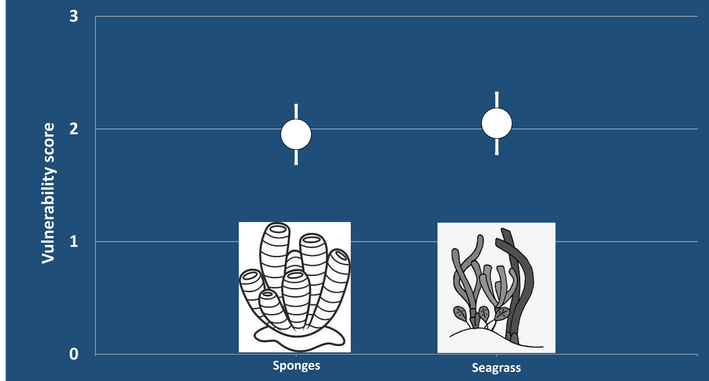

Figure 3: The mean vulnerability score for Sponges and Seagrasses to the oil spill or inorganic pollution stressor, error bars represent standard error. Scores were transformed across studies to a standard 1-3 scale for comparison.

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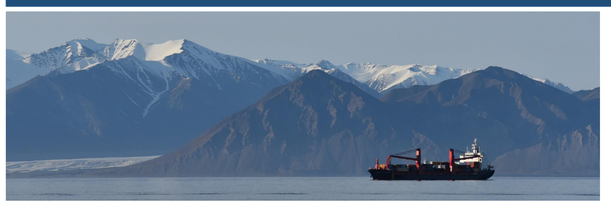

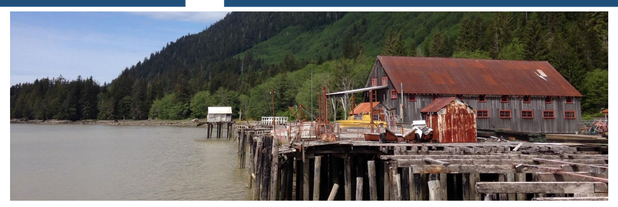

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